Considerations for Cost Estimating Magnet Power Systems

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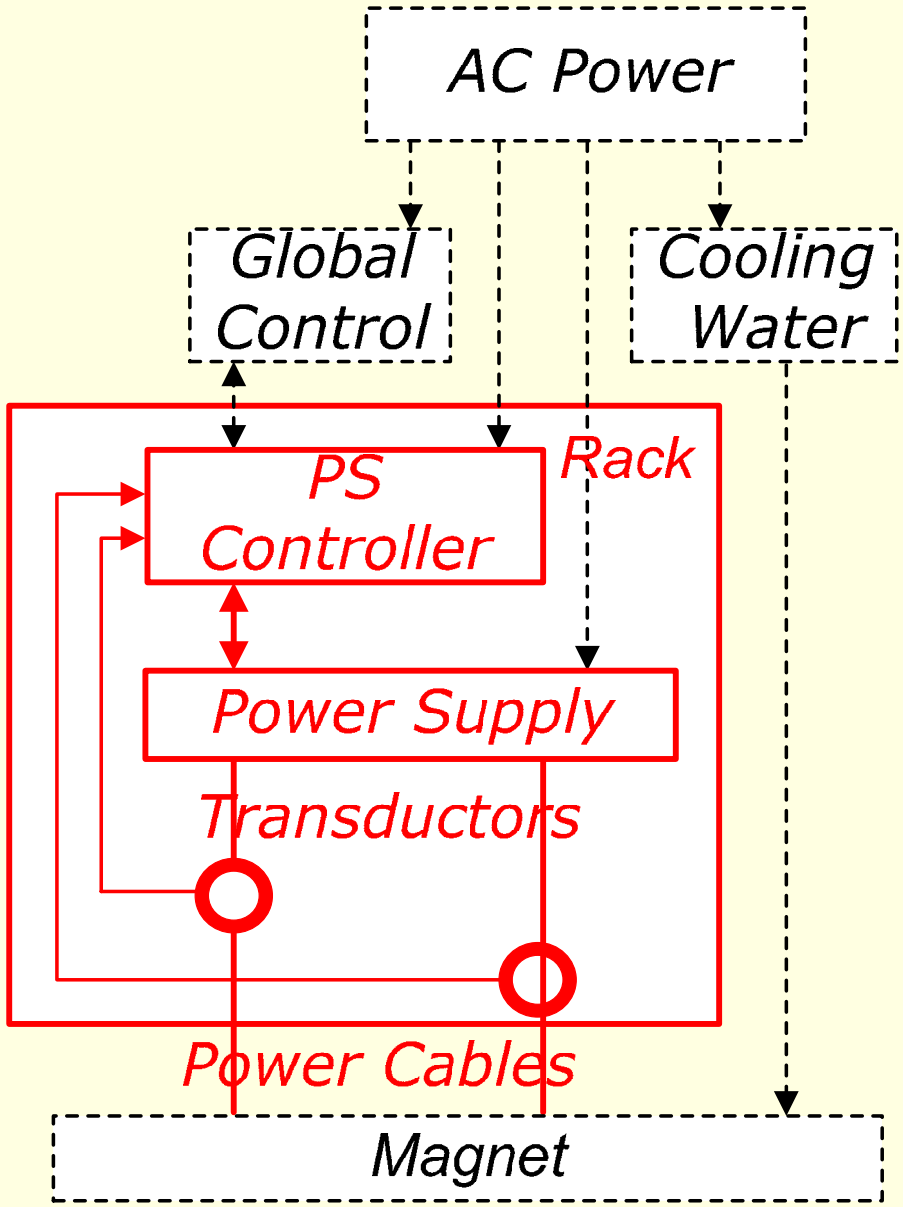
DC Magnet Power System Block Diagram



- Magnet
- DC power cables
- Transductors
- Power supply
- PS controller
- Rack and accessories
- Global control
- Water cooling
- AC power interface

DC Magnet Information

- *Maximum, typical, minimum currents, unipolar or bipolar*
- *Voltage or resistance (0.1 Ω ≤ V/I ≤ 2 Ω)*
- *Series connected (for lower cost) or individual (for insertion or optics)*
- *Stability - short term (ppm RMS vs. time) and long term (ppm / ^{O}C)*
- *Protection (none, thermal or flow switch, etc), individual / group turnoff*
- *Special protection and terminations for superconducting magnets*
- *Mutual coupling with other coils or magnets*
- *Inductance (for tuning, v=di / dt)*

Pulsed Magnet Information

- *Maximum, typical, minimum currents, unipolar or bipolar*
- *Impedance and inductance*
- *Pulse shape (rise and fall times, width) and flattop requirements*
- *Pulse repetition rate (establishes average power)*
- *Timing requirements*
- *Pulse-to-pulse time (jitter) and amplitude stability*
- *Protection (none, thermal switch, flow switch, etc)*
- *Special terminations*

Cables, Raceways and Cable Trays

- *Ampacity per NEC or other standard*
- *Allowable losses ($5\% \le P_c / P_m \le 50\%$) or other heat loading constraints*

  $B = \mu N I / L$ and $P = I^2 R = \rho L / \pi D^2$

  Linear reductions in I yield second order reductions in power
- *Space for raceways / trays, raceway and tray fill per NEC or other AHJ*
- *Conventional or water cooled*
- *Seismic requirements, loading and supports per NEMA VE-1*
- *Low smoke non-Halogen*
- *Voltage class or rating*
- *Shielded, paired or twisted to minimize radiated EMI*
- *Impedance to match load*

DC System Zero Flux Current Transductors

Hitec (in Europe)

Danfysik Model 866

0 - ± 600 A

0.3 ppm / ° C

DC – 100 kHz

10 kA / mS

Danfysik Model 860

0-±1000A, to ±3000A

0.3 ppm / ° C

DC – 100 kHz

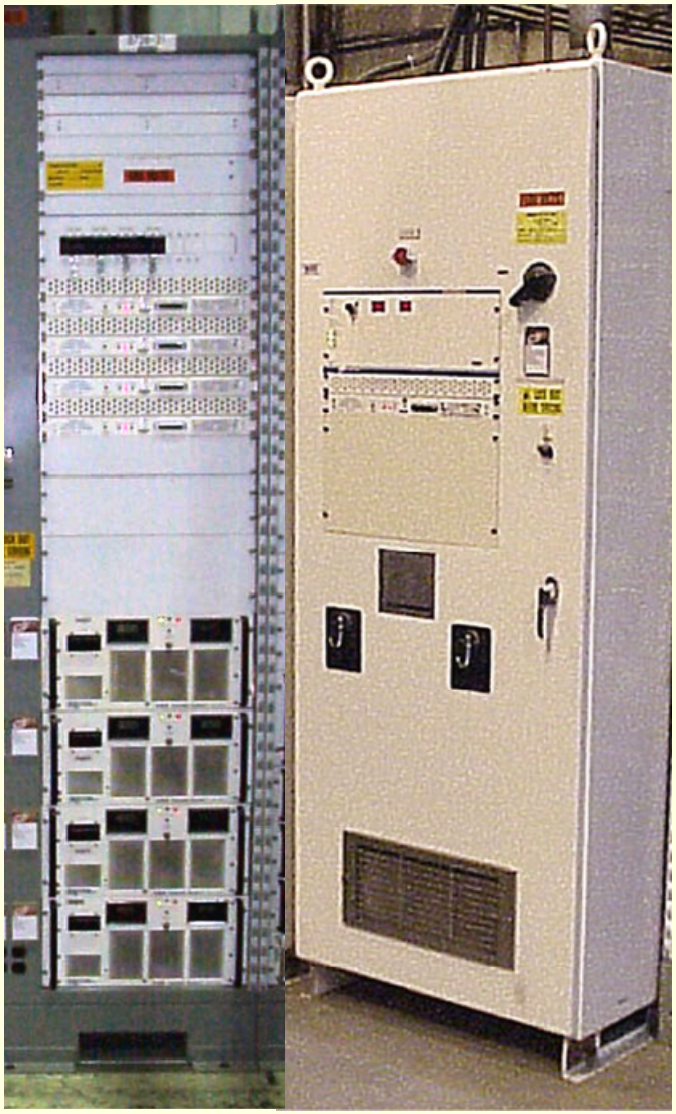
10 kA / mS

Power Output Vs Mounting / Input Voltage / Cooling Considerations

	Input AC (V)				Cabinet		Cooling	
Power Output	1 ϕ 120	3 ϕ 208	3 ϕ 480	3 ϕ 4160	RM	FS	AC	WC
< 2 kW	X				X		X	
2 kW → 5 kW		X			X		X	
> 5 kW → 40 kW			X		X		X	
> 40 kW → 100 kW			X			X	X	
> 100 kW → 1 MW			X			X	X	X
> 1 MW				X		X	X	X

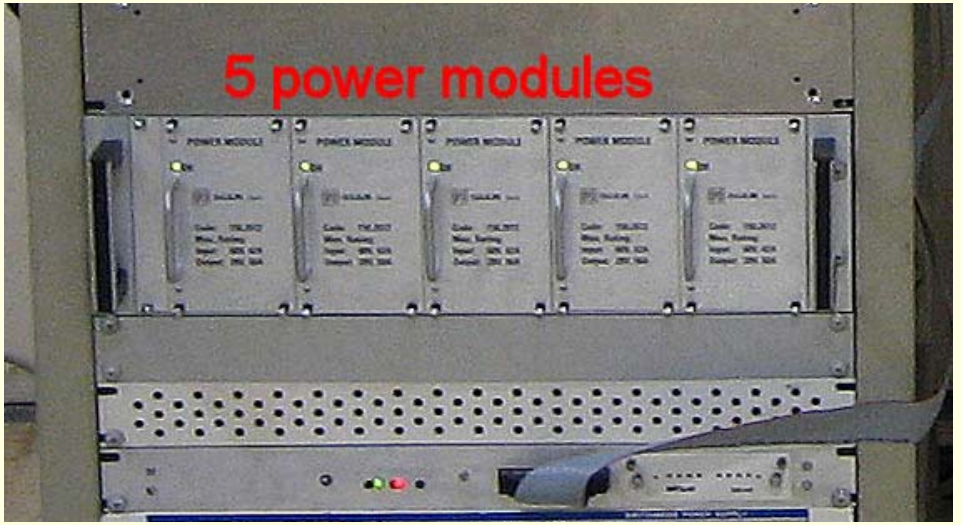
RM = Rack mounted FS = Freestanding

AC = Air-cooled WC = Water-cooled



Other Power Supply Considerations

- *Unipolar, bipolar or four-quadrant output*
- *Redundant to increase availability, modular to reduce number of different types. Some success with ATF2 redundant modular demonstration system*
- *Personal protection system (PPS) requirement*
- *Magnet thermal switch interface*
- *Ambient temperature range*
- *Allowable heat into ambient*



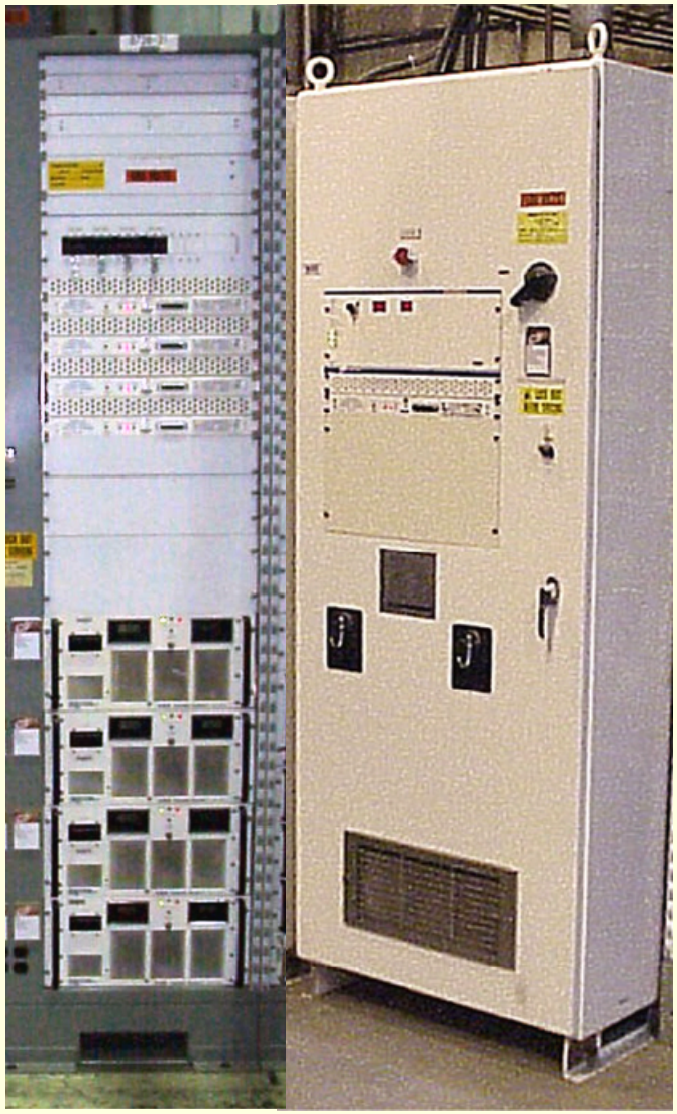
DC - stability

- *Redundant or single*
- *Communication protocol*
- *Analog or digital communication with power supply*
- *Embedded or separate*

Pulsed – interlock protection

- *Programmable logic controller (PLC) based*

Racks and Freestanding Power Supplies



- *Seismic criteria*
- *Size (H * W * D) and weight limitations*
- *Cooling (air or water), air conditioning*
- *Other environmental considerations*

AC Power Interface - Last Slide

- *Voltage class*
- *System impedance*
- *Fault current levels*
- *Minimize arc flash hazard (recessed breakers, extender handles, remote control)*